Root Cause Analysis of BIT False Alarms

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Mr. Kerry Westervelt

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Introduction

- Root cause analysis is an essential task to mature false alarm performance
- Effectiveness of corrective actions is highly dependent upon how well engineers analyze false alarms
- This brief outlines a success-oriented engineering approach on how to perform root cause analysis

Collect and Analyze BIT Indications

- **Step 1: Collect and analyze BIT indications**
  - Collect reports from the Aircraft Maintenance Event Ground Station (AMEGS)
  - Analyze reports using AMEGS Viewer or Naval Aviation Logistics Command Management Information System-Optimized Organization Maintenance Activity (NALCOMIS-OOMA)
  - Decipher fault translation data using interface design document
  - Collate indications with the following items
    - Pre-flight & post-flight test cards
    - Maintenance tie-in reports
  - Verify whether indications have been documented as a false alarm and if they have a completed root cause analysis

Collect and Analyze BIT Indications

Radar Altimeter (RADALT) communication → false alarm in AMEGS report

Unfiltered Summary: All Faults: ALL Types:

AIRCRAFT ID: 164942 Flight: 13/01/03 - 21:26:40 474 Records Displayed: 76 WRA, 214 WCA, 42 EXC, 62 C/MI, 80 SYS

Type	Fault	Occur	S/R	BIT	WO/JCN	Description	IF
C/MI	6300	1	S		No MAF	Hydraulics - PRESS LINE FILTER BYPASS 1 (NIU1)	
SYS	0105	1	S		No MAF	System Discrete - WEIGHT ON WHEELS	
ADVS	4654	1	S		No MAF	FCS - PFCS FAIL RESET (FCC 1)	
ADVS	4654	1	R		No MAF	FCS - PFCS FAIL RESET (FCC 1)	
SYS	0106	1	S		No MAF	System Discrete - WEIGHT OFF WHEELS	
ADVS	6408	1	S		No MAF	*Ice Prot - +4 DEGREES C	
WRA	1880	1	S	F(C)	No MAF	*RADALT - RCVR/XMTR - RADALT	341
ADVS	1800	1	S		No MAF	RADALT - RAD ALT FAIL	
WRA	1880	1	R	(P)	No MAF	*RADALT - RCVR/XMTR - RADALT	341
ADVS	1800	1	R		No MAF	RADALT - RAD ALT FAIL	
ADVS	5825	1	S		No MAF	Engine - L ENG OIL TANK QTY	
C/MI	5903	1	S		No MAF	*Engine - L ENG HIGH OIL USAGE (NIU1)	
ADVS	5825	1	R		No MAF	Engine - L ENG OIL TANK QTY	
C/MI	5903	1	R		No MAF	*Engine - L ENG HIGH OIL USAGE (NIU1)	
ADVS	6408	1	R		No MAF	*Ice Prot - +4 DEGREES C	
SYS	0105	1	S		No MAF	System Discrete - WEIGHT ON WHEELS	
SYS	0106	1	S		No MAF	System Discrete - WEIGHT OFF WHEELS	
SYS	0105	1	S		No MAF	System Discrete - WEIGHT ON WHEELS	
SYS	0106	1	S		No MAF	System Discrete - WEIGHT OFF WHEELS	
ADVS	1005	1	S		No MAF	*Navigation - SAME ATT SOURCE (INS 1)	
ADVS	1005	1	R		No MAF	*Navigation - SAME ATT SOURCE (INS 1)	
SYS	0105	1	S		No MAF	System Discrete - WEIGHT ON WHEELS	
SYS	0106	1	S		No MAF	System Discrete - WEIGHT OFF WHEELS	
SYS	0105	1	S		No MAF	System Discrete - WEIGHT ON WHEELS	
WRA	0A84	1	R	(P)	No MAF	*Intercom - CREW CHIEF ISC	435

Collect and Analyze BIT Indications

Summary Details

Log | Maint Detail

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Maintenance Details: AIRCRAFT ID: 164942, Flight:   13/01/03 - 21:26:40
MAINTENANCE WRA FAULT - DETAILED DESCRIPTION

AIRCRAFT ID:  164942   Download Date:  13/01/03   Download Time:  21:26:40

Fault ID:                1880
WO/JCN:                No MAF
Description:   RADALT - RCVR/XMTR - RADALT
Fault Date:          13/01/03
Fault Time:          19:19:50
Set/Reset:               SET
Maint. Mode:              ON
Bit Mode:               PBIT
WRA Status:          NO COMM

================================================================================

FAULT DATA

ID/1880    1421
   1/0000   2/0000   3/0000   4/0000
   5/0000   6/0000   7/0000   8/0000
   9/0000 10/0000 11/0000 12/0000
 13/0000 14/0000 15/0000 16/0000
 17/0000 18/0000 19/0000 20/0000
 21/0000 22/0000 23/0000 24/0000
 25/0000 26/0000 27/0000 28/0000
 29/0000 30/0000 31/0000 32/0000


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FAULT DATA TRANSLATION

No Fault Data Translation available for non FCC WRAs




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AIRCRAFT STATE DATA

Nacelle Angle:            0.4  deg
OAT:                     -2.0  degC
Altitude:              4062.0  ft
Mag Heading:            -1.23  rad
```

No fault data with communication failures
- All bits set to zero

Attempt to Duplicate Indications

- **Step 2: Attempt to duplicate indications**
  - Run subsystem initiated Built-In-Test (BIT)
  - Perform functional check on subsystem
  - Fly same profile that code set
  - Check equipment on the V-22 electrical system test lab

Verify Equipment Configuration

- **Step 3: Verify equipment configuration**
  - Ensure latest software version
  - Check part numbers and serial numbers
  - Consult configuration with equipment vendor

Analyze BIT Design

- **Step 4: Analyze BIT design**
  - Review interface control document
  - Review BIT description document
  - Review V-22 Integrated Avionics System to the V-22 Maintenance Data Processing System Interface Control Document – Part 2 Software
  - Review BIT Traceability Diagrams
  - Consult with equipment vendor

Analyze BIT Design

RADALT bits

Table I: ABIU to JASS Data Element Table

Source: ABIU			**Destination:** JASS		
Data Element - Description	**Data Type**	**Units**	**Frequency**	**Accuracy**	**Range**
	Size	**Priority**	**Representation**	**Resolution**	**Legality Checks**
	Notes				
RADAR_ALT	INTEGER	FEET	N/A	N/A	0 .. 4500
Provides the radar altitude.	13 BITS	N/A	BIT01 = MSB = 4096, BIT13 = LSB = 1	1	0 .. 4500
	VALID TO 4500 FEET				
RADAR_ALT_CONTROL	BOOLEAN	N/A	N/A	N/A	0..1
Indicates the state of the radar altitude control bit.	1 BIT	N/A	1 = CONTROL BIT SET, 0 = NO INDICATION	N/A	0..1
	None.				
RADAR_ALT_TRANS_VALID	BOOLEAN	N/A	N/A	N/A	N/A
Indicates that the radar altitude transmission between the altimeter and the ABIU is valid.	1 BIT	N/A	0=Valid	N/A	N/A
	N/A				
RADAR_ALT_VALID	BOOLEAN	N/A	N/A	N/A	N/A
Indicates that the radar altimeter data is valid.	1 BIT	N/A	1=Valid	N/A	N/A
	None.				
RECIRCULATION_FAN	BOOLEAN	N/A	N/A	N/A	0..1
THIS WILL INDICATE WHETHER THE RECIRCULATION FAN HAS A FAILURE.	1 BIT	N/A	1 = FAILURE, 0 = NO INDICATION	N/A	0..1
	1 = FAILURE 0 = NO INDICATION				

Analyze Software Design

- **Step 5: Analyze software design - requirements and actual coding**
  - Review Joint Vertical-lift eXperimental (JVX) Avionics Support Software (JASS) software design document
  - Review subsystem software design document
  - Software interface control drawings
  - Check logic associated with interfacing equipment
  - NOTE: Concentrate on BIT thresholds and filtering (i.e., IF / AND statements, time counter functions, and parameter limit comparisons i.e. =, >, <, etc)

Analyze Software Design

RADALT fault processing in JASS software design document

8.4.24 Radar Altimeter Fault Processing

8.4.24.1 Description

This paper establishes detailed software requirements for radar altimeter CIC and data validity.

8.4.24.2 Design

8.4.24.2.1 Radar Altimeter

The radar altimeter consists of a receiver/transmitter, forward antenna, and an aft antenna. The radar altimeter interfaces with the mission computer via the ABIU. Radar altimeter data is passed from the ABIU to the mission computer. When the RADALT goes into search mode the last altitude reading is frozen for up one second.

Failure of the ABIU renders the radar altimeter results unreliable. Radar altimeter data is also unreliable when the aircraft climbs above 5000 feet or maneuvers beyond system limits.

8.4.24.2.1.1 Reference

Document	Reference
ABIU ICD	D901-99507-3
SRS	C000189

8.4.24.2.1.2 Radar Altimeter CIC Processing

The radar altimeter has no SBIT or PBIT, it only uses IBIT. The following messages are used.

Table 180 RADALT DATA

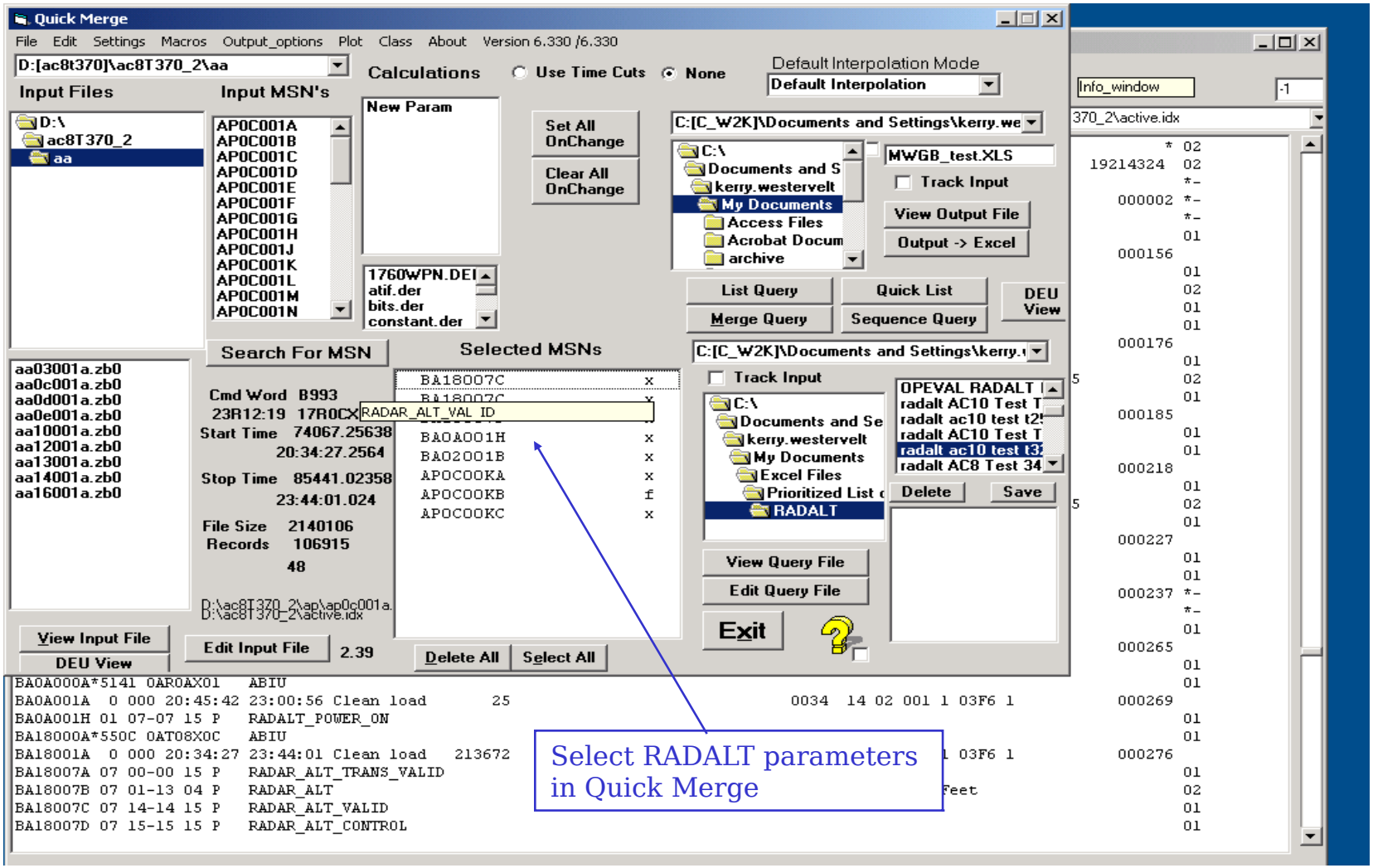
Analyze Software Design

- **Original RADALT BIT Mechanization**
  - RADAR_ALT_TRANS_VALID sets PBIT failure indication, F(C)
    - 20 Hz signal
  - RADAR_ALT_VALID sets PBIT failure indication, F(P)
    - 0.5 second filter on 20 Hz signal
  - RADALT_BIT_INITIATE sets IBIT failure indication, F(T), if:
    - IBIT duration exceeds 4 seconds
    - RADAR_ALT_VALID indicates invalid state
    - RADAR_ALT_TRANS_VALID indicates invalid state
    - RADAR_ALT indicates altitude not between 93 to 107 feet
  - Operator commands RADALT IBIT
    - IBIT only available before engine start
    - ***RADALT contains NO periodic BIT only IBIT***
  - RAD ALT FAIL advisory; set by
    - RADAR_ALT_TRANS_VALID
    - RADAR_ALT_VALID
  - AFCS FAULT advisory; set by
    - RADAR_ALT_TRANS_VALID
    - RADAR_ALT_VALID
  - `RALT TO BALT caution`; set by
    - RADAR_ALT_TRANS_VALID
    - RADAR_ALT_VALID

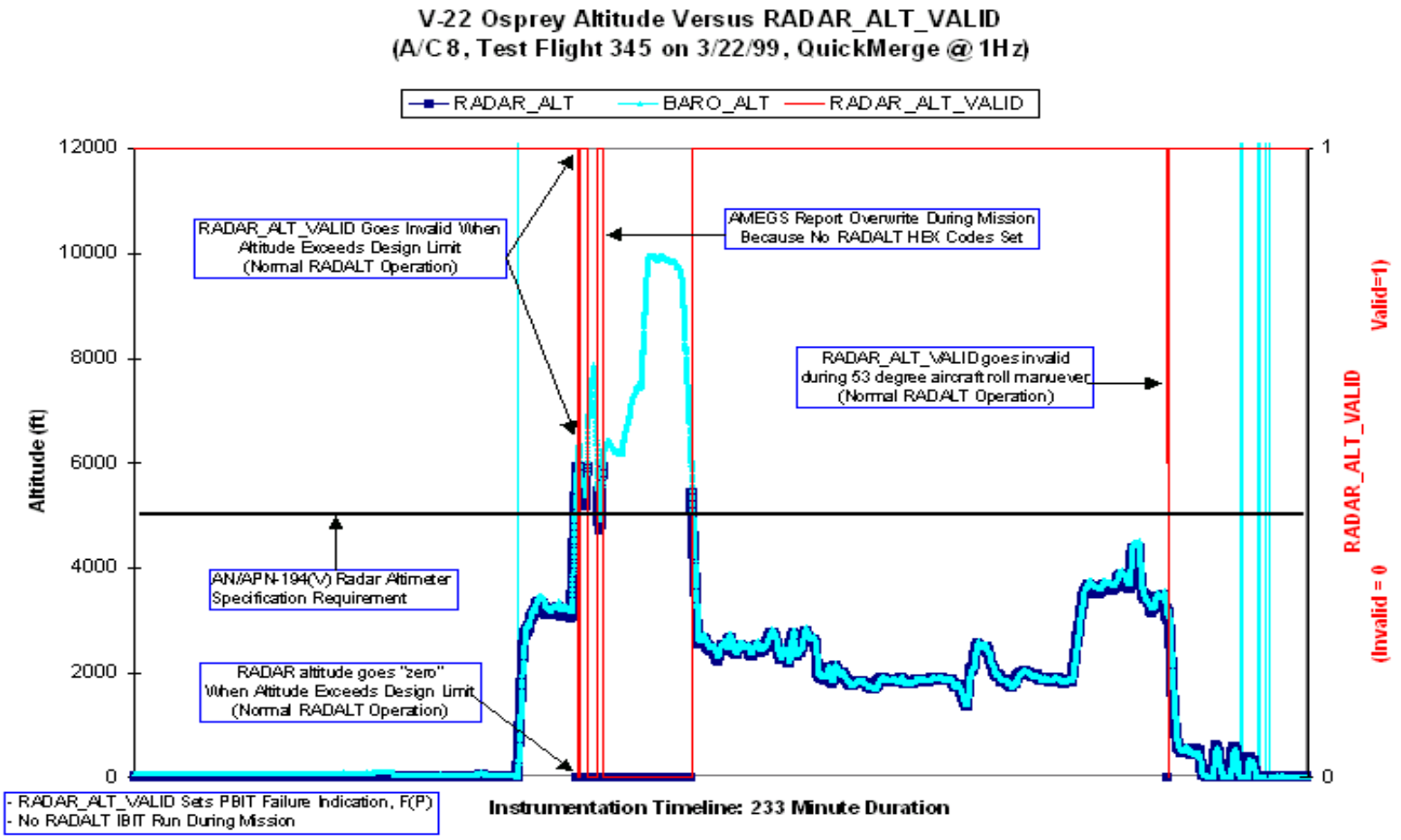
Analyze Quick Merge Data

- **Step 6: Analyze Quick Merge Data**
  - Plot all indications that are reported from subsystem
  - Plot these indications along with AMEGS reported indications
  - Plot aircraft operating parameters
  - Plot indications sent to other subsystems
  - Compare plots to actual software design requirements and actual coding

Analyze Quick Merge Data



Analyze Quick Merge Data


V-22 Osprey Altitude Versus RADAR_ALT_VALID
(A/C 8, Test Flight 345 on 3/22/99, QuickMerge @ 1Hz)
RADAR_ALT
BARO_ALT
RADAR_ALT_VALID
12000
10000
8000
6000
4000
2000
0
Altitude (ft)
1
0
RADAR_ALT_VALID
Valid=1
(Invalid = 0
RADAR_ALT_VALID Goes Invalid When Altitude Exceeds Design Limit (Normal RADALT Operation)
AMEGS Report Overwrite During Mission Because No RADALT HBK Codes Set
RADAR_ALT_VALID goes invalid during 53 degree aircraft roll manuever (Normal RADALT Operation)
AN/APN-194(V) Radar Altimeter Specification Requirement
RADAR altitude goes "zero" When Altitude Exceeds Design Limit (Normal RADALT Operation)
- RADAR_ALT_VALID Sets PBIT Failure Indication, F(P)
- No RADALT IBIT Run During Mission
Instrumentation Timeline: 233 Minute Duration

Return Equipment To Vendor

- **Step 7: Return Equipment to Vendor for Analysis**
  - Provide vendor aircraft operating data with failure indications
  - Stress equipment similar to aircraft conditions
    - Monitor indications using factory test equipment
  - NOTE: Acceptance test procedures in lab sometimes insufficient
  - Coordinate software design requirements and actual coding with vendor
    - Review JASS software design document
    - Review subsystem software design document
    - Software interface control drawings
    - Check logic associated with interfacing equipment
    - NOTE: Concentrate on BIT thresholds and filtering (e.g., IF / AND statements, time counter functions, and parameter limit comparisons i.e., =, >, <, etc)

Corrective Action Plan

- **New RADALT BIT Mechanization**
  - RADAR_ALT_TRANS_VALID sets PBIT failure indication, F(C) ***(Delete PBIT test)***
    - 20 Hz signal
  - RADAR_ALT_VALID sets PBIT failure indication, F(P) ***(Delete PBIT test)***
    - 0.5 second filter on 20 Hz signal
  - RADALT_BIT_INITIATE sets IBIT failure indication, F(T), if:
    - IBIT duration exceeds 4 seconds
    - RADAR_ALT_VALID indicates invalid state
    - RADAR_ALT_TRANS_VALID indicates invalid state
    - RADAR_ALT indicates altitude not between 93 to 107 feet
  - Operator commands RADALT IBIT
    - IBIT only available before engine start
    - ***RADALT contains NO periodic BIT only IBIT***
  - RAD ALT FAIL advisory; set by ***(Rename WCA "RAD ALT INOP")***
    - RADAR_ALT_TRANS_VALID
    - RADAR_ALT_VALID
  - AFCS FAULT advisory; set by
    - RADAR_ALT_TRANS_VALID
    - RADAR_ALT_VALID
  - `RALT TO BALT caution`; set by
    - RADAR_ALT_TRANS_VALID
    - RADAR_ALT_VALID

Conclusions

- **Seven-step process provides logical approach on how to perform root cause analysis of false alarms**
- **Corrective action plans can be developed based upon empirical data to improve their effectiveness**
- **Changes to BIT thresholds and filtering are optimized to the aircraft's operating environment**

NAVAIR

R&M AIR 4.1.6
Reliability and Maintainability

Questions?